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Inmarsat CEO, Rajeev Suri

With Mil-Sat and Over-Sat CEOs Don Richardson and Yosi Albagli

The Luneberg Lens Reborn: A High-Performance ESA at Low-Cost

The quest for a low-cost and highly efficient Electronically Steerable Antenna (ESA) continues to accelerate with the coming of the LEO and MEO constellations. Until now, active and passive ESAs have so far failed to deliver an atenna that combines high gain, large scan angle, low power and low cost.

Meet the first Ku-Band ESA based on the Luneberg lens, in development by U.S. - based Mil-sat and Israeli satellite integrator Over-Sat. The Lens, long considered the ideal refractive medium for RF energy, offers uniform high gain at horizon to horizon scan angles. Now, thanks to the advent of 3 D printing, it becomes a low-cost alternative to conventional technology.

The antenna project, funded under a grant from the U.S. - Israeli Bird Foundation, promises unversal access to the coming generation of NGSO-based broadband. To find out more, we set up a joint interview with the CEOs of Mil-Sat and Over-Sat, Don Richardson and Yosi Albagli.

SMW: I understand the Mil-Sat and Over-Sat and are engaged in a joint effort to develop the first Luneberg lens-based, electronically steered Ku-band satellite antenna. Can you give us a brief background on your companies and how the idea to create the antenna evolved?

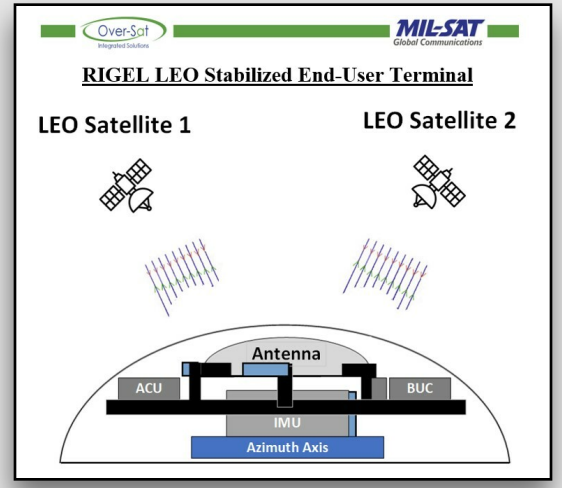
Yosi Albagli: Over-Sat was started in 2014 by former members of Orbit's management team. Our team's extensive experience developing VSATs and marketing thousands of terminals to commercial and military markets has proven invaluable at Over-Sat.

Over-Sat is an ISO-certified satellite systems integrator and a certified supplier to the Israeli Ministry of Defense and the major Israeli defense companies. We provide VSAT solutions to navy vessels, military aircraft, vehicles, and manpacks for soldiers. We are now shifting our focus from VSAT integration only to a mix of integration, solutions, and products – primarily targeted at maritime.

Don Richardson: Mil-Sat been around for seventeen years. In 2004, I quit my engineering job and went to work full-time managing Mil-Sat. We represented Seatel and sold antennas and antenna parts to the U.S. Navy and the cruise line industry, eventually becoming one of the top 5 SeaTel dealers in the world. In 2010, we took on another partner and moved into network services

solutions, teleport services, and product development, including developing antennas for the Navy. Today, we continue to expand our military and commercial business in the LEO market.

In 2017, the U.S. military approached us seeking a real-world solution for 5G integration into a satellite network. During the conversations, we acknowledged the inadequacies of the current antenna solutions. A military's scientific community member suggested we consider developing an Electronically Steered Antenna (ESA) based on a Luneburg lens design. That's how the idea got started.



Recently, the Israeli embassy approached us to participate in the Bird Foundation Grant program, a program in which small U.S. companies team with Israeli small companies to commercialize new technologies.

Since we had already developed plans to build a Luneburg satellite antenna, we saw a Bird grant as the ideal vehicle to fund the development of the antenna. We had some dealings with Over-Sat in the past and saw them as the perfect Israeli partner.

SMW: The Luneberg lens has been around for many years. How does it work, and how has it been used in the past?

Don: Originally, starting in the 1950s, the military used the Luneburg lens primarily in radar applications. It operates on the principle of refraction. It's a sphere or half-sphere made up of numerous layers, each with a different refractive index that increases toward the sphere's center. RF energy passes through the it, and it's focused focal at the line feed.

SMW: How do you steer the beam? Do you physically reposition the line feed or move it electronically?

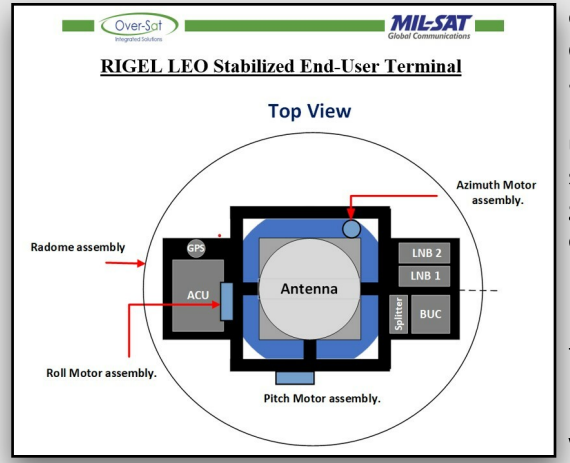
Yosi: Usually, the beam is steered by physically

moving the line feed. However, our antenna version steers the beam electronically in elevation and mechanically in Azimuth, an approach that requires only minimal mechanical components. We can generate multiple beams by adding several line feeds, access two or more satellites simultaneously, and do "make before break," connecting simultaneously to rising and a setting NGSOs.

SMW: How does your Luneberg lens compare with flat-panel Active and Passive Arrays currently in development?

Yosi: The Luneburg lens' unique combination of multi-orbit, multi-frequency capability, uniform high gain at all elevation angles, lightweight, and low manufacturing costs makes it a formidable competitor against other types of ESAs.

Because the Luneburg lens uses refraction, the RF energy is brought to a focal point without the need for the large number of patch antennas characteristic of active phased arrays, thereby reducing cost, power requirement, and heat generated. Luneburg Lens antennas are also very inexpensive to produce.



180-degree horizon to horizon coverage is another significant design advantage vs. flat panel arrays. Over the scan angle, there is no reduction in gain. For vessels using multi-orbit, GEO, and LEO services and sailing high-latitude, great circle routes, GEO connectivity assured, even at low look angles.

Multi-beam capability also makes the antenna suitable for hybrid networks, which will become more popular as LEOs become available. While our initial design is a two-beam Ku-band antenna, a multi-frequency, multi-orbit antenna configuration is also feasible.

SMW: In the past, manufacturing Luneburg lenses was costly. I understand costs have dropped considerably. Why?

Yosi: Unlike active and passive phased arrays, which require years of software development and an extensive staff of programmers, the Luneburg antenna uses refraction for beamforming. So, our software only needs to reposition the line feeds electronically. So, we anticipate reaching the pre-production stage with much less investment than the others.

SMW: I understand that you have just received a $1.0 million grant from the Bird Foundation to develop the antenna. Can you give us some background on the Bird Foundation, its origin, and its objectives?

Yosi: The U.S. and Israeli governments established the BIRD Foundation in 1977 to generate mutually beneficial cooperation between U.S. and Israeli companies, including start-ups and established organizations. BIRD provides matchmaking support between U.S. and Israeli companies, and funding typically covers 50 percent of project development costs, up to $1M per grant project.

SMW: Have you raised any additional funding, or are you currently in the process? What is your ultimate funding objective?

Don: We believe we have sufficient capital to reach the pre-production stage. At that point and based on orders received, we expect to raise the capital required to commence manufacturing. MiL-Sat's affiliate company, CM Technology, has multiple contracts with LEO network operators to build out LEO teleport infrastructure, giving us insight into the LEO network market that most antenna design companies do not have.

SMW: At what stage is the product development? Have you built and tested a prototype?

Don: We're currently in a POC testing of an RX-only antenna in our labs and expect to have a pre-production RX/TX stabilized version capable of tracking two LEO Satellites during 2023. We will soon be starting the development of the beam steering software and integration of the OneWeb second-generation modem, which will be a challenge.

SMW: Based on manufacturing cost, do you see the antenna as only an enterprise-level product, or is their potential for a low-cost, consumer version?

Yosi: Today, we are focused primarily on antennas for the maritime and other mobility segments – principally, enterprise markets. In maritime, we expect to compete against active and flat panel

Yosi is the co-founder and chairman of Over-Sat Ltd., a company that provides integrated solutions in the area of satellite mobile communications. Yosi is also the Chairman of Ethernity Networks (ENET.L: London Stock Exchange).

Prior to co-founding Over-Sat, Yosi served as President of Satellite Communications at Orbit Technologies (TLV: ORBI), responsible for the development, marketing, sales and customer support of

arrays that cost significant sums today. That allows us to offer a higher value product, and generate substantial revenue from sales to niche markets, those that require tens of thousands of antennas. So, we don't currently anticipate entering the market for mass-market consumer antennas.

Don Richardson is MiL-SAT President and Founder.

Prior to founding Mil-Sat, Mr. Richardson established himself as a military communications expert supporting various US DOD & NATO missions with system design and disparate cryptology management solutions.

Don began his career serving in the US Navy as an Electronics Technician, later working as a defense support contractor. Soon after the successful launch of MIL-SAT